INSTALLATION FOR MAKING A NONWOVEN TEXTILE WEB AND METHOD FOR USING SUCH AN INSTALLATION

Background of the Invention and Related Art

The present invention relates to an improved installation for making a nonwoven textile web, which is commonly referred to by the generic name of spunbond and which is formed by continuous synthetic filaments. The invention also relates to a method for using such an installation.

The production of nonwoven webs of the spunbond type is known in the art and generally includes the following steps.

a) Extruding a melted organic polymer through a spinneret perforated with holes, so as to form a bundle or curtain of filaments.

b) Orienting the extruded filaments by drawing using one or more compressed-air fluid-jet devices.

c) Receiving the bundle of filaments in the form of a web on a movable transporting belt, which is generally subjected to a suction source and the speed of which is adjusted according to the characteristics of the web, in particular weight per unit area, which it is desired to achieve.

After production, the web is consolidated, for example by performing a sizing or calendering. Preferably hot calendering is used so that the elementary filaments are joined to one another.

Other consolidation treatments may also be performed. For example, a needling treatment (conventional or by fluid jets) may be used, and/or the deposition of a bonding substance may be applied on the surface or in the interior of the web.

A great number of proposals have been made for producing such webs, all having the aim of obtaining a

web or sheet as homogeneous as possible with a high productivity and, increasingly, with elementary filaments of great fineness having a count less than 2 dtex, if possible.

Among the oldest documents for producing such webs, mention may be made of the patent GB-A-932 482, in which the filaments, after extrusion, move along in the open air on leaving the spinneret over a sufficient distance to permit at least surface solidification of the extruded filaments before they are introduced into a suction and drawing nozzle creating the formation of a high-speed annular air current.

In order to break-up of the bundle of filaments, the latter receive an electrostatic charge which may be obtained from an electrostatic generator. This causes a corona-type effect upstream and downstream of the suction nozzle.

Among the various parameters which must be taken into account for the production of good-quality webs, it is necessary, depending on the extruded polymers, to adapt the distance between the outlet of the spinneret and the inlet into the drawing system, the air speed inside the nozzle and also the exit speed of the filaments from the latter, so that the deposition on the receiving belt is regular or homogeneous.

To solve the problem of the homogeneity of the deposition on the conveyor belt, it has been proposed in the US patent 3,286,896 to design the suction device in the form of a narrow chamber of rectangular cross-section and of great length. Such an assembly includes at the inlet a suction chamber for the extruded filaments, followed by an additional chamber where low-pressure air is injected and a channel of great length wherein the high-speed air flows. In order to obtain a good distribution of the filaments over the receiving surface, a deflecting assembly

which slows the air flow is arranged at the outlet of the drawing chamber, to permit a better distribution of the filaments.

Such systems in which the filaments pass inside a suction and drawing chamber of rectangular shape, which may, where appropriate, have the width of the web of extruded filaments, have been proposed in US 3,802,817 and corresponding French patent 2,064,087. The curtain of filaments is subjected on both of its sides to the action of high-speed air streams causing the filaments to be drawn.

US patent 4,064,605 also describes an improvement to such a technique which includes an additional assembly for cooling the filaments. The bundle of filaments is cooled by contact with a transverse air current before introduction into the actual drawing chamber.

Finally, the development of the technique has led to the provision of installations in which the drawing of the filaments at the spinneret outlet and their transfer to a receiving belt are achieved without the filaments ever going into the open air at the spinneret outlet. This is achieved by an integrated assembly making it possible to achieve the cooling, drawing and disposition of the filaments on the belt, as disclosed US patents 4,627,811 and 5,814,349.

Such an installation design makes it possible to obtain nonwoven sheets with a low weight per unit area and good regularity, but it is complex and difficult to use.

Moreover, such installations lack versatility due to the fact that it is not possible to readily adjust the cooling conditions at the spinneret outlet. Such conditions vary according to the polymers and the filament count which it is desired to produce, and the final characteristics of the web.

In addition, such installations are ill-suited to the production of filaments of great fineness.

Consequently, to date, no satisfactory solution has been proposed for designing an installation for producing nonwovens of the spunbond type with which it is possible to achieve a high productivity when the filaments are fine. That is, a spunbond nonwoven having a count less than 2 dtex, which means having a perfect and extremely regular drawing of the filaments without breakage thereof during this drawing phase.

Now, to achieve a high productivity, that is to say a high polymer delivery at the spinneret outlet, this means on the one hand that increasing the drawing speed in the drawing slot, thus entailing a high air flow rate coupled with a relatively high temperature of the filaments before drawing in order to preserve a certain plasticity thereof.

Furthermore, drawing of the filaments coupled with a high productivity also means being able to brake the air streams at the outlet of the drawing slot to achieve a regular deposition of the filaments on the receiving conveyor and the production of a high-quality sheet.

Summary of the Invention

In accordance with the invention, a novel type of installation is provided for producing nonwoven textile webs from continuous synthetic filaments, with which all the above-mentioned problems can be solved.

Generally speaking, the installation according to the invention is of the type comprising, in a conventional manner, the following.

- At least one extruder for feeding a melted organic polymer to a spinneret for producing a curtain of filaments.
- A cooling zone for bringing about at least

surface solidification of the extruded filaments.

- A suction device in the form of a narrow chamber of rectangular cross-section, inside which the curtain of filaments is subjected to the action of high-speed air streams causing the filaments to be drawn.
- An arrangement for deflecting and slowing down the air flow at the outlet of the drawing slot and for distributing the filaments homogeneously over a receiving belt.

The installation according to the invention is characterized in that the devices and/or techniques for carrying out the different operational phases, namely extruding, cooling, filament-drawing assembly and distributing, are separate from one another and can be independently adjusted. Such adjustment is possible, not only according to the production to be achieved (nature of the polymers, elementary count of the filaments produced, weight per unit area of the web produced), but also during the start-up phase of the production.

By virtue of such a design, which is contrary to the technical development in this field, directed towards producing completely integrated assemblies for the cooling, drawing and distribution of the filaments over the conveyor belt, it was found that such a separation of the different operational phases from one another afforded a very great number of advantages. Such advantages particularly include the flexibility of use and the possibility of adjusting the production much more easily according to the yarn counts and the web weight which it is desired to achieve.

Advantageously and in practice, according to the invention:

- The cooling zone at the spinneret outlet and

the filament-drawing zone include a plurality of elementary modules placed side by side according to the production width. The filament-opening system includes an assembly extending over the entire width of the web produced.

- The cooling at the spinneret outlet is brought about by an assembly having a plurality of successive zones for subjecting the curtain of filaments to a transverse air current. The speed and temperature of the air current may be adjusted independently in each of the zones.
- The filament-drawing device includes a suction slot, having a width which may be adjusted automatically according to the production of the machine.
- The filament-opening system, which is spaced from the outlet of the drawing system, includes an assembly which laterally deflects the air flow, to reduce the speed thereof and that of the filaments. This facilitates the uniform deposition of the filaments on the conveyor by eliminating any rebound at the moment of this deposition. Advantageously, the filament-opening system is also associated with an assembly which electrostatically charges the filaments before deposition on the receiving belt and which may be arranged either immediately at the outlet of the opening system or integrated inside the latter.
- The installation is arranged for computer control of all of the subassemblies to make it possible to bring about the increase in speed of the production line automatically.

The invention also relates to a method for using such an installation, which method is characterized by the following features.

(a) During the start-up phase, the temperature of the air inside each cooling zone decreases from one zone to the next. It is possible for the speed of the traversing air in each zone to be adjusted and to be between 0.5 m/second and 3 m/second with the drawing slot being maintained in the separated position,

(b) The production speed is then increased progressively. The parameters of the zone for cooling

and heating up the filaments may be modified to:

- increase the air speed in the first zone, the temperature remaining unchanged,
- increase the temperature in the second zone to bring it to the level of that of the first zone and increase the air speed in this zone,
- increase the air temperature in the third zone and increase the air speed in this zone; and simultaneously, the width of the drawing slot is progressively reduced to attain a nominal operating value, with the pressure of the drawing air being progressively increased.

It should be noted that in the method according to the invention, the air temperature inside each cooling zone is generally in a range extending from 5°C to 60°C.

<u>Brief Description of the Drawings</u>

The invention and the advantages which result therefrom will be better understood with reference to the following exemplary embodiment which is given by way of guidance but without limitation, and which is illustrated by the attached Figs., in which:

Fig. 1 is a general view of an installation designed in accordance with the invention;

Fig. 2 is a schematic detail view of the assembly for cooling or more precisely controlling, the temperature of the filaments before introduction into the actual drawing slot; and

Fig. 3 is a schematic elevational view showing the general structure of a drawing slot.

<u>Detailed Description of the Drawings</u>

Referring to the attached Fig. 1, the installation according to the invention is composed essentially of at least one extruder which feeds synthetic polymer, such as polyamide, polyethylene, polyester, etc., to a spinneret 2 for the formation of a curtain of filaments 3.

From a practical point of view, by way of guidance, the spinneret may consist of a perforated plate containing 5000 holes, for example of 0.5 mm diameter, per meter of width. These holes are distributed over a plurality of parallel rows, for example over eighteen rows, and over a width at the spinneret outlet of 140 mm.

At the outlet of this spinneret is arranged the cooling assembly 4 for adjusting the temperature of the filaments depending on the polymer and which, according to the invention, is composed of three successive zones 4a, 4b and 4c. The zones are arranged to contact the curtain of filaments 3 with traversing air flows. The speed and temperature of the air flows may be adjusted.

For example, the length of the cooling zone is in the order of 1200 mm and the temperature and speed of each of the zones decreases from the first zone 4a to the third zone 4c.

The temperature of the air in this zone will generally be between 15 and 60°C, the speed of the traversing air being between 0.5 m/s and 3 m/s.

Downstream of this cooling zone is arranged the actual drawing assembly 5. The drawing assembly 5 is in form of a closed enclosure having a slot 6 into which air is injected under a pressure of 0.5 to 1.5 bar.

Generally speaking, such a drawing system may be designed in a manner similar to the teachings of FR 1 582 147 or GB 932 482 (Figure 3), with which it is possible to bring about the suction of the curtain of filaments and its entrainment by high-speed air streams enabling drawing to be performed.

As can be seen from Fig. 3, in which the drawing assembly 5 is represented schematically, the latter is composed essentially of an actual drawing slot or chamber 10. The air from a collector 11 is introduced into the chamber 10 through a distributor 12 and an accelerating chamber 13.

Such a suction/drawing assembly is, however, preferably designed so that the width (F) of the slot 10 can be modified by adjustment device 10a during the operation of the installation, which makes it possible on the one hand to adjust the flow rate of the air streams and, consequently, the fineness of the count which it is desired to achieve and on the other hand facilitates the start-up operation as will be seen hereinbelow.

In general, for a production of filaments having

a count of between 1.5 dtx and 3 dtx, the width (F) of the slot will be between 3 mm and 10 mm, it being possible to increase this slot gap to 25 mm during the start-up phase.

At the outlet of the drawing assembly 5, the bundle of filaments 3 is projected onto the receiving belt 7, not directly as disclosed in FR patent 2,064,087 or US patent 4,064,605, but through an assembly 6. The assembly 6 causes the air jet leaving the slot 5 to be deflected and slowed down, leading to the opening of the curtain of filaments and the distribution of these filaments over the receiving belt 7.

Such an assembly may, for example, be in the form of a slot with divergent walls.

Furthermore, to intensify the break-up of the curtain of filaments and the random distribution over the receiving surface, these filaments may be electrostatically charged be means of a system of the "corona" type which is associated with the distribution element 6, in a manner similar to the teachings of British patent 932482.

Where appropriate, the means for electrostatically charging the filaments may be integrated in the inlet of the divergent walls of the distributor 6.

<u>Exemplary embodiment</u>

Using an installation of the type illustrated in the drawings, a nonwoven web consisting of continuous filaments is produced from polypropylene, in the present case 38 MSR. The polymer is melted in an extruder with five melting zones and at the outlet of the extruder, it is filtered on a filter composed of stainless steel mesh before being introduced into the actual spinneret 2.

To do this, the machine has two spinnerets 2 arranged in series, each containing 5000 holes of 0.5 mm diameter per meter of width.

Furthermore, according to the invention, the cooling zone 4 and the drawing zone 5 preferably consist of a plurality of elementary modules each having a width of

50 cm.

On the other hand, the distributing element or assembly 6 arranged at the outlet of the drawing zone 5, has a continuous slot extending over the entire width of the installation and having the form of a divergent nozzle. The width of the slot in the assembly 6 is 15 mm opposite the zone in which the filaments leave the drawing assembly 5 and 100 mm opposite the receiving belt 7.

The distributing assembly 6 may, where appropriate, be associated with additional apparatus for also electrostatically charging the filaments, thus improving the break-up of the bundle and the distribution of these filaments over the receiving belt 7.

The line is started up at low production with a polymer delivery set at 0.2 g/min and per hole.

During this start-up phase, the following parameters are observed in the heating-up zone, by using a cooling zone 4 comprising three successive zones 4a, 4b and 4c that has a total length of about 1200 mm. The extruded bundle of filaments 3 is subjected to a traversing air current coming from each of these zones, in the following conditions:

- zone (4a)
  -air temperature: 35°C
  -air speed: 1 m/second
- zone (4b)
  -air temperature: 20°C
  -air speed: 1 m/second
- zone (4c)
  -air temperature: 15°C
  -air speed: 0.5 m/second

During this start-up cooling phase, the width (F) of the drawing slot 10, is set at 25 mm, the pressure of the air injected into the slot being 0.3 bar.

The drawn bundle passes, at the outlet of the drawing slot 10, into the assembly 6 for the opening and distribution of the bundle. The assembly 10 is in the form of a divergent nozzle, having a width at the inlet of 20 mm and an opening at the base in the order of 100 mm.

Throughout this start-up period, the polymer is collected on the conveyor belt 7 by means of a "leader" (not shown) which is unrolled over the belt and which avoids the clogging thereof by the drops of melted polymer.

When a uniform polymer delivery is established in the spinneret, the production speed of the line is increased progressively.

Throughout this period of increasing speed, the parameters of the zone (4) for cooling and heating up the filaments are progressively modified, namely:

- increase in the air speed in the first zone 4a to 1.5 meters/second, the temperature remaining unchanged;
- increase in the air temperature in the second zone 4b which is raised to 30° C, its speed being raised to 1.3 meters/second; and
- increase in the air temperature in the third zone 4c to 20° C and increase in the speed which is raised to 1 meter/second.

Such a procedure makes it possible to ensure at least surface solidification of the extruded filaments, which do not stick to one another as they enter the drawing slot 5.

With regard to this drawing slot 10, throughout the start-up period, its width is progressively reduced from 25 mm to 5 mm and, simultaneously, the pressure of the drawing air is progressively increased from 0.3 to 1 bar, approximately.

The temperature of the drawing air is controlled and remains constant throughout this period.

By virtue of such a procedure, it is possible to produce, from and installation in which the different zones remain fixed relative to one another, polymers of different nature and also to facilitate the production of filaments having a very fine count of the order of 1.7 dtex, or even less.

This is so because progressively raising the temperature of the air used in the last two cooling zones 4b and 4c makes it possible to increase the plasticity of the polymer and thus facilitates the drawing thereof, allowing greater fineness of the

filaments.

Finally, the fact of being able to adjust, while in operation, both the pressure of the drawing air and the width of the drawing slot makes it possible to optimize the drawing conditions, which, of course, results in the achievement of a high production combined with the production of very fine filaments.

The structure of the filament-opening system, arranged downstream of the drawing system and independent thereof, also promotes regular and homogeneous deposition of the filaments on the receiving surface 7.

This is so because, with the production of filaments with very fine counts being accompanied by a high speed, in the order of 5000 m/min, of the filaments at the outlet of the drawing slot, the device 6 used in the installation according to the invention makes it possible to slow down the speed of the filaments and also of the air flow leaving the drawing slot, promoting their distribution over the conveyor belt due to the fact that it eliminates rebound phenomena liable to disrupt regular and homogeneous deposition.

All of the adjustments of the unit are performed and controlled automatically by a process computer which operates on the so-called "fuzzy logic" principle allowing a multitude of independent parameters to be taken into account.

The concrete example given above makes it possible to obtain filaments having a count of 1.7 dtex with a polymer delivery of 0.65 g/hole/minute.

The sheets obtained can weigh from 10 to 150 g/m^2, are very regular, and may be used for various applications such as hygiene products (nappies for babies), and products for medical or industrial use.

While such an installation makes it possible to obtain filaments with very fine counts, it is also possible of course to markedly increase the production of the line when the filament count is increased.

By way of illustration, if in the above example, filaments having a count of 2 dtex had been produced,

it would have been possible to increase the polymer delivery to 0.8 g/hole/minute.